Fermilab LHC - Quality Assurance

- How did we define quality?
  - For LHC quality is based on fitness for use.
- Quality requirements (a.k.a. design inputs) were defined by CERN and US-LHC.
  - Documented in the LHC Parameters and Layouts database and in the Technical Design Handbook (TDH).
- See section 6.2 of the QA Plan.

Fermilab LHC - Quality Assurance

- How do we ensure we have fulfilled the quality requirements?
  - Design outputs, i.e. drawings & specifications, document that the requirements have been met;
  - Reviews, such as this one, help us to determine if we have missed anything;
  - Q2P1 validated the design and production process.

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- How did we document our QA program for the project?
  - The US-LHC PMP states in section 4.2.10:

"... The QA programs for each component of the US Project will be developed within the context of the relevant laboratory's normal QA program and procedures..."

  - Our approach was to combine the CERN defined requirements with our existing Technical Division QA program;
  - Worked with Jim Kerby and Phil Pfund;
  - The result is the QA Plan you currently have.

Fermilab LHC - Quality Assurance

- Technical Division organization:
  - Departments directly involved with LHC:
    - Machine Shop;
    - Material Control - provides procurement, incoming inspection, warehousing and kitting;
    - Engineering & Fabrication;
    - Development & Test - provides the final measurements of the devices.

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- Section 4 Documents and Records;
  - TD uses its normal systems to control documents and records;
    - ER/ECO - drawings are formally approved, issued, distributed, and revisions are controlled;
    - Documents relating to production are under document control (distribution maintained and revisions controlled);
      - travelers, forms, operating procedures.

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- Section 4 (con't)
  - Records from production are scanned and indexed in OnBase, and are available over the WWW;
    - Data point: we estimate there are at least 1750 pages of production records for each complete cryostated assembly (travelers, DR's, kit lists);
  - Data from quench and magnetic measurements are stored in a database.

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- We also have unique CERN-defined requirements:
  - All drawings will be provided to CERN, and will eventually reside in EDMS;
  - All records for the production of devices will be provided to CERN, and will eventually reside in EDMS;
  - Measurement data and results will be provided to CERN...
- See section 4 of the QA Plan.

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- Section 5 Work Processes:
  - TD uses its normal systems for managing work processes, e.g. travelers, operating procedures (OPs), discrepancy reports (DRs);
    - TD travelers:
      - define the sequence of fabrication, inspections and testing to be performed for the devices;
      - provide witness/hold points for critical tasks;
      - provide sign-off and date at each completion of fabrication sequence, welding operation and inspection/test operation.

5.5 Record the Length from the Outer Edge of the Lead End Plate to the Outer Edge of the Non-lead End Plate before welding.

All Quadrant lengths must be with in .030" of each other.

Position of the Measurement	Measurement in Inches	Range
Q1	225.812	225.801" to 226.301"
Q2	225.813	225.801" to 226.301"
Q3	225.875	225.801" to 226.301"
Q4	225.812	225.801" to 226.301"

Technician(s) — Date: 12/15/2000

X 5.6 Verify that the End Plates are properly installed as per the Final Coldmass Assembly (ME-369578).

Production Engineer/Designee — Date: 12/15/00

5.7 While the Non-lead End Plate is in position as per the Final Cold Mass Assembly (ME-369578), weld the Non-Lead End Plate to the Cold Mass Skin.

Weldor — Date: 12-16-2000

5.8 Clean the Weld area with a Stainless Steel Wire Brush (Fermi stock 1246-0860), Isopropyl Alcohol (Fermi stock 1920-0300), Kimwipes (Fermi stock 1660-2500) or equivalent and vacuum.

Technician(s) — Date: 12/16/2000

5.9 While the Lead End Plate is in position as per the Final Cold Mass Assembly (ME-369578). Weld the Lead End Plate to the Cold Mass Skin.

Weldor — Date: 12-16-2000

5.10 Clean the Weld with a Stainless Steel Wire Brush (Fermi stock 1246-0860), Vacuum, Isopropyl Alcohol (Fermi stock 1920-0300) and Kimwipes (Fermi stock 1660-2500) or equivalent.

Technician(s) — Date: 12/16/2000

5.11 Record the Length from the Outer Edge of the Lead End Plate to the Outer Edge of the Non-lead End Plate after welding.

For Reference only.

Position of the Measurement	Measurement in Inches	Nominal
Q1	225.750	225.926"
Q2	225.750	225.926"
Q3	225.750	225.926"
Q4	225.750	225.926"

Technician(s) — Date: 12/18/2000

6.0 Bolt and Bullet Installation

6.1 Apply Areolex (open Purchase - Chemical Research Co.) to all threaded parts being installed onto the End Plates except the bolts. Apply anti-seize to the Axial Preload Bolts (MB-369267)

Technician — Date: 12-18-00

6.2 Assemble the Bullet Assemblies (MD-369293) for the Lead and Non-Lead End.

Technician — Date: 12-18-00

6.3 Install the Bullet Pusher Screws (MB-344583) and the Bullet Load Slugs (MB-344584) in (4) places on the Lead End and (4) places on the NON-Lead End as per (ES-369708). Be careful not to damage the wires or the solder connections. Only tighten to "Finger Tight".

DR# 0156

Technician — Date: 12-21-00

6.4 Perform a Check of the Bullet Strain Gauges at 0 Pressure in accordance with (ES-369708).

Inspector — Date: 21 DEC 2000

6.5 Torque the Axial Preload Bolts while monitoring the Bullet Pusher Screw Strain Gauges as per (ES-369708).

Note(s):

Before the final torque is applied the Production Engineer and/or Magnet Physicist are to be present.

Technician — Date: 12 3400

X 6.6 Verify the stabilization of the Torque applied to the Bullet Pusher Screws. If no anomalies occurred during this process, state "no anomalies", else comment below.

Comment:

Responsible Authority/Physicist — Date: 1-2-01

6.7 Send the Bullet Strain Gauge Data to the Process Engineering Sever.

Technician: N/A — Date

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- Travelers (con't)
  - Travelers have proven extremely valuable for being able to reproduce the same item over and over;
  - These are living documents, and evolve as we learn;
  - They provide us with a record of what we did, and so they are one of the first things we review if problems arise (which, of course, never happens);
  - We have developed, and are using, ~25 travelers in the cold-mass production process.

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- Operating procedures define the operations for a specific process or piece of equipment, e.g. coil winder;
- TD discrepancy reports:
  - are used to document problems during assembly or fabrication;
  - the cause of the problem is identified and recorded;
  - the device in question is dispositioned, e.g. repair, scrap, use as-is;
  - action(s) are identified and implemented to prevent the problem from recurring.
- See section 5.4 and Appendix II of the QA Plan.

1) Traveler Title:	2) Specification No.:	3) Revision:	4) DR No.:
LHC Cold Mass Final Assembly	5520-TR-333498		HGQ-0158

5) Step No.:	6) Drawing No. & Revision:	7) Serial/Component/Item/Batch/Lot No.:
7.2	5520-ME-369578	MQXB-001

8) Nonconformance Description by First Hand Observer: ☐ Class I ☑ Class II

Bullets were below specs.given by Rodger Bossert.

9) Name Steve Gould Date: 1/3/01

10) Cause of Nonconformance:

"Creep" in bullet readings due to stress relaxation of coils.

11) Responsible Authority Rodger Bt Date: 1/3/01

12) Disposition:

Tighten axial preload bolts to bring bullet reading back into spec.

11) Responsible Authority Rodger Bt Date: 1/3/01

13) Corrective Action to Prevent Recurrence:

Add step to traveller to retighten bullets at this point in operation.

11) Responsible Authority Rodger Bt Title: Engineer Date: 1/3/01

14) Corrective Action/Disposition Verified By:

Rodger Bt

11) Responsible Authority Date: 1/3/01

[ ] Class I [ ] Class II

Will Configuration be affected? [ ] Yes [ ] No

15) Reviewed By:

Bob Jhuss 2/22/01

Process Engineering Manager Date:

16) ☒ Material ☐ Manpower ☐ Method ☐ Machine ☐ Measurement

Process Engineering determine (identify), appropriate problem area and check.

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- Section 8 Inspection & Acceptance Testing:
  - Inspection & testing comes in 3 flavors:
    - Incoming - Material Control's QC Lab IB4;
      - CMM, optical comparitors, dimensions, et cetera (QCRs).
    - In-process - Engineering & Fabrication ICB;
      - Includes dimensional measurements, as well as electrical and leak checking (travelers and DRs).
    - Final - Measurement & Test Facility (MTF) IB1;
      - Quench and magnetic properties of the devices.
  - See section 8.2 of the QA Plan.

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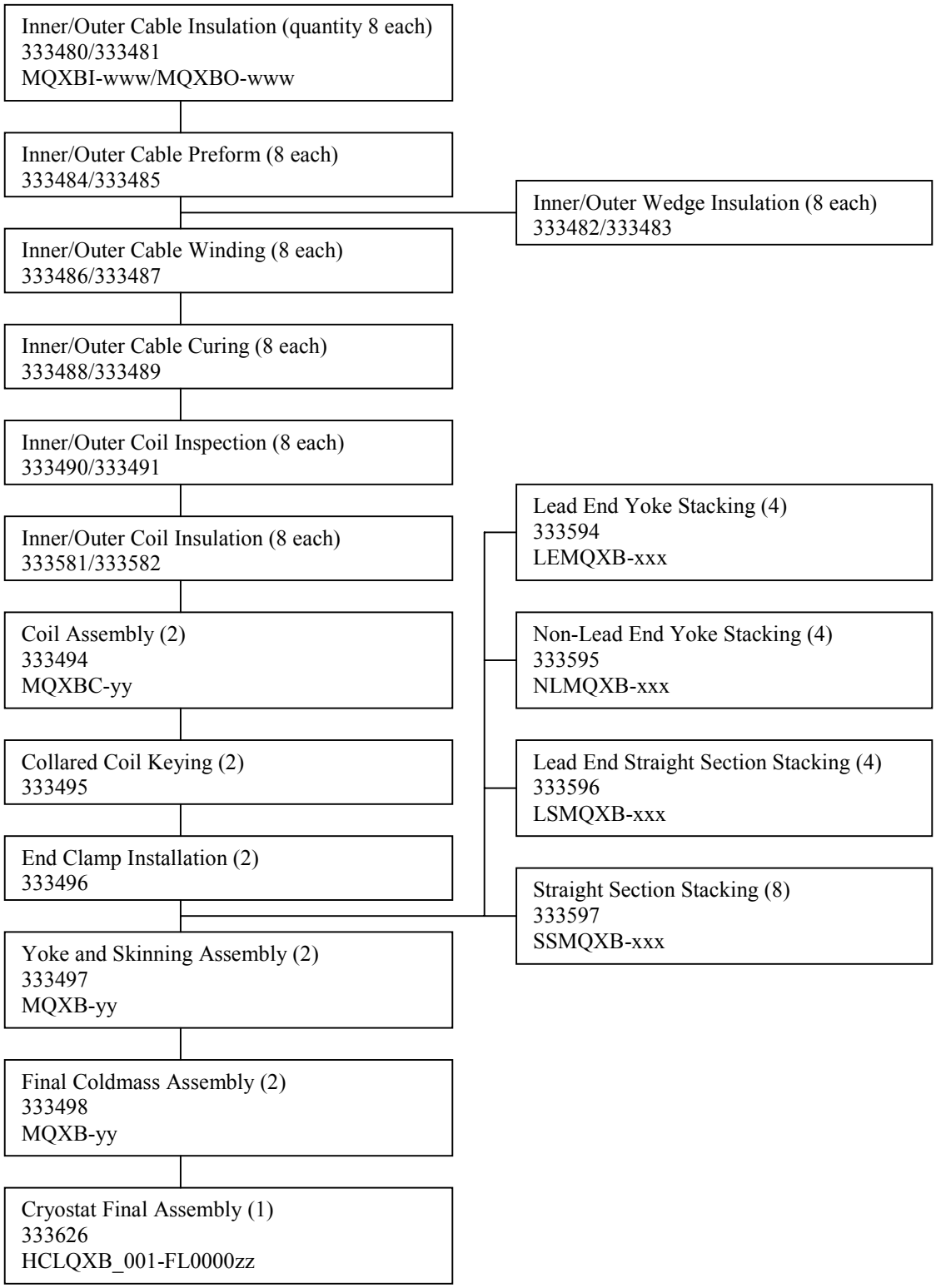
- Appendix II Workflow:
  - Provides a very high level look at the production process;
  - Includes traveler numbers as well as our serialization scheme;
  - It should be noted that we use the TD serialization scheme for the entire process, and then use the CERN-defined scheme to identify the completed assembly.


Inner/Outer Cable Insulation (quantity 8 each)
333480/333481
MQXBI-www/MQXBO-www
Inner/Outer Cable Preform (8 each)
333484/333485
Inner/Outer Wedge Insulation (8 each)
333482/333483
Inner/Outer Cable Winding (8 each)
333486/333487
Inner/Outer Cable Curing (8 each)
333488/333489
Inner/Outer Coil Inspection (8 each)
333490/333491
Lead End Yoke Stacking (4)
333594
LEMQXB-xxx
Inner/Outer Coil Insulation (8 each)
333581/333582
Coil Assembly (2)
333494
MQXBC-yy
Non-Lead End Yoke Stacking (4)
333595
NLMQXB-xxx
Collared Coil Keying (2)
333495
Lead End Straight Section Stacking (4)
333596
LSMQXB-xxx
End Clamp Installation (2)
333496
Straight Section Stacking (8)
333597
SSMQXB-xxx
Yoke and Skinning Assembly (2)
333497
MQXB-yy
Final Coldmass Assembly (2)
333498
MQXB-yy
Cryostat Final Assembly (1)
333626
HCLQXB_001-FL0000zz

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- Summary:
  - Travelers, OPs and DRs aid to control the production process;
  - Documents and records are controlled;
  - Inspections are completed throughout the entire process.
  - All the other details are found in the QA Plan.

THANK YOU